BULLETIN 628 JUNE, 1942

Labor, Power, and Machinery on Small Farms in Ohio

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AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

CONTENTS

ACKNOWLEDGMENTS

This study was made in cooperation with the Bureau of Agricultural Economics of the United States Department of Agriculture.

The authors are indebted to J. I. Falconer of the Ohio Agricultural Experiment Station and Frank T. Hady, B. R. Hurt, and Ellis Kimble of the Bureau of Agricultural Economics for helpful suggestions in the preparation of this report, and to John D. Thewlis of the Ohio Agricultural Experiment Station for valuable assistance in summarization of the statistical data.

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F. L. MORISON[1] AND ROSS V. BAUMANN[2]

INTRODUCTION

The 20-year period 1920-1940 witnessed a rapid increase in the mechanization of farms in Ohio. During that period, the number of tractors on Ohio farms increased nine times, while the number of work horses was cut nearly in half.

Prior to the middle thirties, the purchase of tractors had been limited principally to the larger farming units. Scarcely anyone questioned the place of the tractor on farms of 160 or more acres. In recent years, however, the introduction of small tractors has stimulated the interest of operators of small farms. More and more questions are being raised concerning the relative economy of horses and tractors on small farms.

PURPOSE OF STUDY

This study was made to secure information on the labor, power, and machinery resources of relatively small farms; to determine the costs and advantages of operating such farms with different types of power; and to make possible recommendations for reducing their operating costs.

DESCRIPTION OF THE AREAS

Data were obtained by personal interviews with farmers in Miami County in western Ohio and Medina County in northeastern Ohio. These counties were chosen as being fairly typical of the agriculture in their respective parts of the State. In Miami County, a 3-year rotation of corn, wheat, and hay or rotation pasture prevails; in Medina County, a 4-year rotation of corn, oats, wheat, and hay is most common. Some oats are raised in Miami County, and in both areas soybeans partially replace corn or oats in the rotation, and hay is sometimes held over an extra year or more.

A dairy-poultry type of farming prevails in Medina County; a general livestock type, in Miami. The sources of farm income during the period 1935-1939 and the proportion which each source contributed to the gross cash income were as follows: in Medina County—dairying 47 per cent, poultry 18 per cent, wheat 7 per cent, potatoes 7 per cent, truck crops 5 per cent, hogs 4 per cent, all others 12 per cent; in Miami County—dairying 25 per cent, hogs 18 per cent, cattle 12 per cent, wheat 12 per cent, poultry 10 per cent, corn 8 per cent, all others 15 per cent.

Four representative townships in a contiguous area in the west central part of Medina County and five in the northeastern part of Miami County were selected for study. The topography of the two areas is similar, ranging from level to gently rolling. The soils of Medina County are heavier in texture and have poorer natural drainage than those in Miami County.

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METHODS OF STUDY

It was necessary to set certain limits to the size of farms to be included in the study. The lower and upper limits were placed arbitrarily at 50 and 109 acres. It was felt that it was within this range that most questions were being raised concerning the advisability of owning a tractor. This range of size was also well adapted to statistical analysis; when the sample was broken down into three size groups, the medians of these groups were 60, 80, and 100 acres, sizes of farms common in Ohio.

Practically all operators of farms ranging in size from 50 to 109 acres were contacted in the townships chosen for study in these two areas. Thus, bias in the selection of farmers was eliminated. A total of 147 records was secured in Miami County, 135 in Medina County. The records, obtained during April, May, and June 1940, covered the calendar year 1939. Information was secured on crops raised, livestock kept, and the source, amount, and annual cost of labor, power, and farm machinery used. The number of farms, their classification as to size in acres, and the number having different types of power are shown in table 1.

TABLE 1.—Number of farm records, grouped according to size of farm and type of power, Miami and Medina Counties, Ohio, 1939

Size of farm, acres	Horses only	Horses and tractors		Tractors only	Total
		Standard	General-purpose		
Miami County					
50- 69	20	4	7	3	34
70- 89	29	21	22	6	78
90-109	8	7	16	4	35
Total	57	32	45	13	147
Medina County					
50- 69	22	5	4	6	37
70- 89	30	28	4	6	68
90-109	13	14	3	.....	30
Total	65	47	11	12	135

LABOR

SOURCES AND AMOUNTS OF LABOR

Farm operator.—The average age of operators of the 147 Miami County farms was 48.3 years, that of the 135 Medina County operators, 51.9 years. There was a tendency for younger farmers to operate larger farms and older men to operate smaller ones.

In Miami County, 21 of the farm operators devoted less than full time to their farms. Seventeen of these worked away from the farm a total of 104 months; three operators gave only part time to the farm because of age or ill health; and one woman farmed with hired labor. In Medina County, 24 operators put in less than a full year's work on the farm. Fifteen of these had a total of 120 months of employment off the farm; eight spent less than full time because of sickness or other handicaps; and one woman operator farmed with hired labor.

Family labor.—Seventy-eight of the 147 operators in Miami County and 75 of the 135 operators in Medina County reported the use of some family labor during 1939. No family labor was used on 65 per cent of the 50-69 – acre farms, 46 per cent of the 70-89 – acre farms, and 31 per cent of the 90-109 – acre farms in Miami County, on 51 per cent, 46 per cent, and 33 per cent of the farms of corresponding size in Medina County. Most of those reporting the use of family labor had 3 months or less of it, about what would be done by a boy of school age (table 2).

TABLE 2.—Distribution of 147 Miami County farms and 135 Medina County farms according to size in acres and months of family labor used, 1939

Months of family labor	Number of farms, by size in acres			All farms
	50–69	70–89	90–109	
Miami County				
None	22	36	11	69
0.1-3	9	27	12	48
3.1-9	3	10	10	23
9.1 and over	.....	5	2	7
Total	34	78	35	147
Medina County				
None	19	31	10	60
0.1-3	12	21	11	44
3.1-9	3	10	5	18
9.1 and over	3	6	4	13
Total	37	68	30	135

On many farms, family labor was utilized because it was available, not because it was necessary. In such cases, labor has been charged that would not be included were a comparison being made of the labor actually required with different types of power.

Hired labor.—Eighty-seven of the 147 Miami County farmers and 68 of the 135 in Medina County hired some labor in 1939. Only 2 of the Miami County operators, both of whom were employed at work off the farm, hired full-time men; the other 85 hired an average of a little less than one-half month each. Twelve operators in Medina County hired year-round men; the other 56 hired an average of 1.5 months per farm. The weighted average wage paid for all hired labor, including day laborers and men employed on a monthly basis, was $40 per month in Miami County, $25 per month in Medina County.

Total labor.—Although a considerable number of operators spent less than full time at farming, operators as a group performed a large part of the work on the farms in this study. In Miami County, operators' labor amounted to 81 per cent of the total, compared with 70 per cent in Medina County, where there was a larger proportion of older operators and more opportunity for full-time work off the farm. Family labor was used to a smaller extent in Miami County, furnishing 16 per cent of the total labor supply, compared with 19 per cent in Medina County. Hired labor, averaging only about one-half month per farm in Miami County, provided only 3 per cent of the labor there, whereas in Medina County, an average of 1.7 months of hired labor per farm amounted to 11 per cent of the total.

TABLE 3.—Total man labor per farm, 147 farms in Miami County and 135 farms in Medina County, Ohio, grouped according to type of power and size of farm, 1939

Area and size of farm in acres	Months of labor per farm				
	Horses only	Horses and tractors		Tractors only	All farms
		Standard	General-purpose		
Miami County					
50- 69	12.0	13.3	12.4	8.5	11.9
70- 89	14.4	14.2	13.5	13.8	14.0
90-109	17.5	14.8	13.7	12.7	14.7
All farms	14.0	14.2	13.4	12.2	13.7
Medina County					
50- 69	14.1	16.1	12.1	10.5	13.6
70- 89	15.3	15.8	14.8	13.1	15.3
90-109	17.0	15.5	18.1	.....	15.1
All farms	15.2	15.8	14.7	11.8	15.1

The total amount of labor increased with an increase in size of farm, the type of power remaining constant (table 3). There was little difference between the amounts of labor used on farms having horses alone and those with horses and standard tractors. There was, however, some tendency for farms operated with horses and general-purpose tractors to use less labor than those operated with horses alone or horses and standard tractors (see also appendix table II.

WORK ACCOMPLISHED PER MAN

The substitution of mechanical power for labor is greater than the relatively small differences in the amounts of labor used per farm would indicate, since farms operated with horses and tractors generally had more cropland and more animal units[3] of productive livestock than those operated with horses alone (table 4).

In measuring labor efficiency, number of productive man work units[4] per farm is a more satisfactory measure of size of farm business than either total acres or crop acres, because of differences in the relative acreage of corn or other intensive crops and variations in the amount and kind of livestock kept on farms of the same acreage. Work units are a measure of what is accomplished, not of how hard a farmer works.

More work was accomplished per man on farms with horses and standard tractors than on farms operated with horses alone, and when general-purpose tractors were substituted for standard tractors, labor efficiency was further increased. In Miami County, farmers who owned no horses accomplished the greatest amount of work per man. This was not true for the group in Medina County not owning horses. Several of these men were part-time farmers; several were underequipped; several had more family labor than was necessary to operate their farms; and most of the farms were low on livestock.

[3]An animal unit is a mature cow or its feed-consuming equivalent in other livestock. Productive animal units, reported in table 4, do not include work horses.

[4]A man work unit is the amount of work accomplished by one man in a 10-hour day, using horses and the tools and practices common to his locality.

TABLE 4.—Labor efficiency as related to type of power and size of farm, 147 Miami County and 135 Medina County, Ohio, farms, 1939

Item	Miami County				Medina County			
	Horses only	Horses and tractors		Tractors only	Horses only	Horses and tractors		Tractors only
		Standard	General-purpose			Standard	General-purpose	
50-69 acres								
Number of farms	20	4	7	3	22	5	4	6
Per farm:								
Crop acres	45	52	49	53	34	38	44	31
Animal units	12.4	11.9	12.6	4.6	8.8	14.7	15.3	7.2
Man work units	206	234	225	167	156	246	219	117
Number of men	1.0	1.1	1.0	.7	1.2	1.3	1.0	.9
Per man:								
Crop acres	45	47	47	75	29	28	44	36
Man work units	205	212	218	236	132	183	218	134
70-89 acres								
Number of farms	29	21	22	6	30	28	4	6
Per farm:								
Crop acres	63	65	72	68	41	48	53	34
Animal units	16.4	17.6	18.4	18.1	11.0	14.2	12.5	9.2
Man work units	270	282	297	311	198	246	265	151
Number of men	1.2	1.2	1.1	1.2	1.3	1.3	1.2	1.1
Per man:								
Crop acres	52	55	64	59	31	36	43	31
Man work units	225	238	263	271	155	187	215	139
90-109 acres								
Number of farms	8	7	16	4	13	14	3	.....
Per farm:								
Crop acres	80	79	81	85	54	56	57	.....
Animal units	22.1	14.2	20.2	19.1	14.2	17.3	23.4	.....
Man work units	321	279	325	327	233	272	341	.....
Number of men	1.4	1.2	1.1	1.1	1.4	1.3	1.5	.....
Per man:								
Crop acres	55	61	71	81	38	44	38	.....
Man work units	221	226	284	309	165	211	226	.....

HORSES

Of the 147 Miami County farms studied, 57 were operated with horses, 77 with horses and tractors, and 13 with tractors only; 65 of the 135 Medina County farms were operated with horses, 58 with horses and tractors, and 12 with tractors only.

HORSES PER FARM

The average number of horses per farm increased with increased size of farm (table 5). The farms in Miami County operated with horses only had an average of 2.9 horses per farm, compared with 2.3 horses on the same class of farms in Medina County. The latter group of farms, however, had less cropland; so there was less difference between the two areas in the number of crop acres handled per horse.

In both areas, horse-and-tractor farms of a given size had more cropland than comparable farms operated with horses only. In Miami County, there was a considerably greater reduction in number of horses per farm when a standard tractor furnished part of the power than there was in Medina County, but in neither area was there any tendency for farms operated with horses and general-purpose tractors to have fewer horses than those operated with horses

TABLE 5.—Average number of horses, total acres, and crop acres per farm, on farms grouped according to size in acres and type of power, Miami and Medina Counties, Ohio, 1939

Item	Miami County			Medina County		
	Horses only	Horses and tractors		Horses only	Horses and tractors	
		Standard	General-purpose		Standard	General-purpose
50-69 acres						
Number of farms	20	4	7	22	5	4
Per farm:						
Total acres	58	57	58	59	57	59
Crop acres	45	52	49	34	38	44
Work horses	2.5	1.8	2.0	2.2	2.0	1.8
70-89 acres						
Number of farms	29	21	22	30	28	4
Per farm:						
Total acres	79	80	79	77	78	79
Crop acres	63	65	72	41	48	53
Work horses	3.0	2.1	2.1	2.3	2.2	2.5
90-109 acres						
Number of farms	8	7	16	13	14	3
Per farm:						
Total acres	98	97	98	98	99	99
Crop acres	80	79	81	54	56	57
Work horses	4.0	2.4	2.2	2.5	2.1	2.3
All farms						
Number of farms	57	32	45	65	47	11
Per farm:						
Total acres	74	81	83	75	82	77
Crop acres	59	67	72	41	49	51
Work horses	2.9	2.2	2.1	2.3	2.2	2.2

and standard tractors. On these general-purpose tractor farms, a two-horse team was generally used to do such work as mowing, raking, hauling hay, hauling manure, and the like. A few of these farmers were still keeping a third horse, used little if any, but kept because it was old and of little sales value.

The numbers of farms having one, two, three, four, or five horses each are reported in appendix table III.

AGE OF HORSES

The average age of work horses in each of these two areas was about 13 years. Miami County farms of 50-69 acres had horses with an average age of 13.5 years, those of 90-109 acres, horses averaging 11.2 years. In Medina County, the corresponding figures were 14.6 and 12.2 years. In Medina County, there were less than half enough horses 3 to 5 years of age to replace the present number of those 6 to 8 years old, and in Miami County, only one-third enough.

COST OF HORSE WORK

The amounts of feed and the total costs per horse varied only slightly, regardless of the type of power used (table 6). Many farmers failed to take advantage of practices which would have reduced feed cost, the largest item in the cost of keeping horses. Horses on farms equipped with tractors worked less, and a large part of this reduction was in heavy work, such as plowing,

disking, and cutting grain. Cost per hour of work done by horses was greatest on farms having general-purpose tractors; on these farms, horses performed approximately one-half of the total drawbar work.

TABLE 6.—Amounts of feed and costs per horse on 123 Medina and 134 Miami County, Ohio, farms grouped according to type of power, 1939

Item	Miami County			Medina County		
	Horses only	Horses and tractors		Horses only	Horses and tractors	
		Standard	General-purpose		Standard	General-purpose
Farms with horses	57	32	45	65	47	11
Crop acres per farm	59	67	72	41	49	51
Horses per farm	2.9	2.2	2.1	2.3	2.2	2.2
Value per horse	$66	$61	$75	$86	$86	$69
Feed per horse:						
Corn, bushels	31.0	30.0	28.5	15.0	16.0	19.0
Oats, bushels	1.5	.6	1.7	31.0	29.0	26.0
Hay, tons	1.7	1.9	1.8	2.4	2.4	2.5
Other forage, tons*	1.8	2.1	2.4	1.0	.9	1.0
Cost per horse:						
Grain	$18.79	$17.93	$17.38	$19.30	$18.85	$19.72
Roughage†	23.31	27.26	26.42	26.76	26.81	26.06
Miscellaneous‡	1.95	1.67	1.61	1.66	1.70	1.58
Interest	3.30	3.05	3.75	4.30	4.30	3.45
Depreciation	14.33	12.50	13.61	12.48	13.43	11.00
Total	61.68	62.41	62.77	64.50	65.09	61.81
Manure credit	6.00	6.00	6.00	6.00	6.00	6.00
Net annual cost§	55.68	56.41	56.77	58.50	59.09	55.81
Work per horse, hours	469	447	397	537	444	362
Cost per horse per hour§	.12	.13	.14	.11	.13	.15

*Stover and straw.
†Hay, stover, straw, and pasture.
‡Shoeing, veterinary and breeding fees, etc., but no charge for man labor or shelter
§Excluding shelter and labor of feeding and caring for horses.

Farmers in Miami County not owning tractors had an average of 2.9 work horses per farm, and those owning general-purpose tractors had 2.1. The total horse costs on these farms were $164 and $121, respectively. In Medina County, the number of horses was reduced even less, and horse costs were $135 and $122 per farm, respectively, on the two types. Thus, if there is to be any reduction in labor and power costs on small farms, particularly those of less than 90 acres, on which horses are to be kept after a tractor is purchased, it appears that the economy must be found largely in some item other than reduction in the number of horses.

TRACTORS

Operators of small farms in Medina County began to use tractors somewhat earlier than those in Miami County (table 7). In both areas, the adoption of tractors has been rapid during the past decade, particularly in Miami County. On a number of farms in each area, horses were no longer owned although a few farmers not owning horses had to rely on the use of neighbors' horses for some operations for which they had not yet purchased tractor equipment. Standard tractors reached their peak in numbers in Miami County in 1935, but not until 4 years later in Medina County. Very few of them are being sold at present.

TABLE 7.—Farms 50 to 109 acres in size classified as to type of power, 1920 to 1940

Area and year	Farmers operating with horses	Farmers owning tractors					
		Horses and tractors		Tractors only		Total farming with tractors	
		Standard	General-purpose	Standard	General-purpose		
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Per cent*
Miami County							
1920	144	3	.....	.....	.....	3	2.0
1925	140	7	.....	.....	.....	7	4.8
1930	122	22	3	.....	.....	25	17.0
1935	85	45	15	.....	2	62	42.2
1937	65	38	37	2	5	82	55.8
1939	57	32	45	2	11	90	61.2
1940*	55	32	44	2	14	92	62.6
Medina County							
1920	128	7	.....	.....	.....	7	5.2
1925	118	17	.....	.....	.....	17	12.6
1930	101	33	1	.....	.....	34	25.2
1935	91	41	2	1	.....	44	32.6
1937	83	42	5	3	2	52	38.5
1939	65	47	11	5	7	70	51.8
1940*	57	43	18	5	12	78	57.8

*More tractors may have been purchased before the season was over, especially in the Miami County area, as the records were secured there in April and May, 1940, in June in Medina County.

Sixty-one per cent of the farms studied in Miami County and 52 per cent of those in Medina County had tractors in 1939. Only 41 per cent of the 50-69 – acre farms in each area were so equipped, compared with 77 and 57 per cent, respectively, of the 90-109 – acre farms in Miami and Medina Counties.

AGE AND TYPE OF TRACTORS

The average age of all tractors was 7.4 years in Miami County and 10.4 years in Medina County. More of the tractors in use in 1939 in the Miami area were of the general-purpose type, whereas those in the Medina area were largely standard tractors (table 8).

TABLE 8.—Number, average age, and value of tractors, by type, on 90 Miami County and 70 Medina County, Ohio, farms, 1939

Item	Standard* two-plow	General-purpose		All tractors
		Two-plow	One-plow	
Miami County				
Number of tractors	35	53	2	90
Average age, years	12.5	4.4	1.0	7.4
Inventory value	$156	$560	$548	$403
Medina County				
Number of tractors	53	10	8	71
Average age, years	13.2	3.3	1.2	10.4
Inventory value	$180	$734	$573	$302

*The term "standard tractor" refers to the four-wheel type, unadapted for row-crop field work. One crawler type and three homemade tractors in Medina County and one homemade tractor in Miami County are included in this category.

SECONDHAND TRACTORS

Forty-six per cent of the tractors in Miami County and 56 per cent of those in Medina County had been purchased secondhand. Ninety-one per cent of the standard tractors in Miami County and 70 per cent of those in Medina County were bought secondhand, compared with one-sixth of the general-purpose tractors in each area. Tractors of the latter type made their appearance in Ohio a decade later than standard tractors.

There was a distinct tendency for operators of the 50-69-acre farms to purchase more of their tractors secondhand. The increasing supply of used tractors makes tractor ownership possible on many small farms. Such tractors generally can be used for several years and can be purchased for much less than new tractors. Their chief disadvantage lies in their being less dependable, requiring more repairing than new tractors, and, in addition, lacking many improvements found on later models. Even so, the small farmer lacking in capital but possessing mechanical ability may find it more economical to purchase the used outfit.

Sixty per cent of the secondhand standard tractors were purchased for less than $200 each (table 9). Twenty-two tractors costing less than $100 each, an average of $67, were 10 years old when bought. The average age of all secondhand standard tractors at the time they were purchased was 7.6 years. Secondhand general-purpose tractors were higher in price; their average age at time of purchase was only 2.8 years.

TABLE 9.—Distribution of standard and general-purpose tractors in use in 1939, classified according to purchase price when bought new or secondhand, Miami and Medina Counties, Ohio

Purchase price	Type of tractor					All tractors
	Standard		General-purpose			
	Two-plow		Two-plow		One-plow	
	New	Secondhand	New	Secondhand	New	
Dollars	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Under 100	.....	22	.....	.....	.....	22
100- 199	.....	20	.....	.....	.....	20
200- 299	.....	15	.....	1	.....	16
300- 399	.....	4	.....	2	.....	6
400- 499	.....	3	.....	4	1	8
500- 599	1	2	.....	2	6	11
600- 699	4	.....	9	2	2	17
700- 799	6	.....	13	1	.....	20
800- 899	5	1	10	.....	1	17
900- 999	1	1	14	.....	.....	16
1,000-1,099	1	1	4	.....	.....	6
1,100 and over	1	.....	1	.....	.....	2
All tractors	19	69	51	12	10	161

WORK DONE BY TRACTORS

In 1939, approximately 80 per cent of the tractor farms in Miami County had less than 250 hours of tractor use each, and a like proportion of those in Medina County had less than 200 hours (fig. 1).

Tractors were used an average of 200 hours per tractor farm in Miami County and 159 hours in Medina County. In the latter area, the 50-69-acre

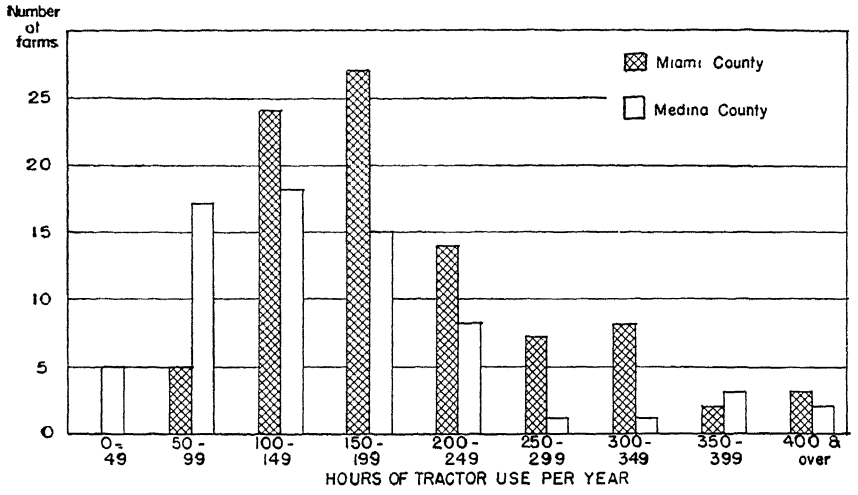

Fig. 1.—Farms with tractors grouped according to hours of tractor use, 90 farms in Miami County and 70 farms in Medina County, Ohio, 1939

farms were the only group on which general-purpose tractors predominated, and this condition accounted for the relatively greater tractor use on farms of that size (table 10).

TABLE 10.—Hours of tractor use on farms grouped according to size, Miami and Medina Counties, Ohio, 1939

Item	50–69 acres	70–89 acres	90–109 acres	Total
Miami County				
Number of farms	34	78	35	147
Number with tractors	14	49	27	90
Hours per tractor farm:				
Drawbar, on farm	149	177	200	179
Belt, on farm	2	6	11	7
Total on farm	151	183	211	186
Work off farm	39	9	9	14
Total, all work	190	192	220	200
Medina County				
Number of farms	37	68	30	135
Number with tractors	15	38	17	70
Hours per tractor farm:				
Drawbar, on farm	165	123	149	139
Belt, on farm	7	12	7	9
Total on farm	172	135	156	148
Work off farm	8	9	20	11
Total, all work	180	144	176	159

In the Miami County area, tractors were used to perform 35 per cent of all drawbar work, as compared with 25 per cent in Medina County. The only operations for which the Medina County farmers used tractors more exten-

sively than Miami County farmers were harrowing and miscellaneous drawbar work on all farms as a whole, planting corn, mowing hay, and hauling hay and manure on farms of 50-69 acres (appendix table IV).

Miami County farmers owning no work horses used their tractors for a larger proportion of several field operations than did those in Medina County (appendix table V). Those in the latter area, however, used tractors more extensively for hauling manure, hauling hay, and other drawbar work. Thus, in each of the two areas, the operators who owned no horses performed 87 per cent of their drawbar work with tractors. Most of the remaining 13 per cent of this work was done by neighbors' horses in exchange for tractor work, and a small amount of farm hauling was done by trucks.

In both areas, general-purpose tractors performed considerably more of the field work than did standard tractors. Operations where there was not much difference in the proportion of work done by these two types of tractors were plowing, disking, and cutting grain.

COST OF TRACTOR OPERATION

The cost of operating tractors was made up in large part of fuel costs and depreciation (table 11). The latter was less in total amount and in relation to other costs for standard tractors than for the newer general-purpose tractors. There may have been some bias in favor of the old standard tractors, in that a farmer has no such basis for estimating the life of a new tractor as has the farmer with one 10 or 15 years old.

TABLE 11.—Relation of size and type of tractor to annual and hourly costs on 70 Medina and 90 Miami County farms, Ohio, 1939

Item	Standard two-plow	General-purpose	
		Two-plow	One-plow
Number of tractors	88	63	10
Average age of tractor, years	12.9	4.2	1.1
Average value of tractor	$170	$588	$568
Hours of use per year:			
Drawbar	127	216	238
Belt	15	10	5
Total	142	226	243
Costs per year:			
Cash expense:			
Fuel	$ 27.16	$ 31.55	$ 26.24
Oil	6.19	4.95	3.82
Repairs	4.09	2.19	
Taxes and insurance	2.55	8.82	8.52
Total	39.99	47.51	38.58
Other expense:			
Depreciation	23.44	45.65	42.78
Interest	8.50	29.40	28.40
Total	31.94	75.05	71.18
Total annual cost*	71.93	122.56	109.76
Cost per hour	.51	.54	.45
Cash expense	.28	.21	.16
Other expense	.23	.33	.29
Fuel per 10 hours, gallons	17.2	13.0	9.4
Oil per 10 hours, quarts	3.2	1.5	1.1

*Excludes charge for shelter and operator's labor.

Depreciation amounted to 33 per cent of the annual cost of standard two-plow tractors, 37 per cent with general-purpose two-plow tractors, and 39 per cent with general-purpose one-plow tractors. Fuel costs were 38, 26, and 24 per cent, respectively, of the annual cost of these three types of tractors. Total costs were 51 cents per hour of use for standard tractors, 54 cents for general-purpose two-plow tractors, and 45 cents for general-purpose one-plow tractors.

The smaller tractors were used a larger number of hours, which offset their relatively greater depreciation charges. The fuel consumption per 10 hours of work was considerably less for the one-plow tractors because of the lighter tasks performed, improvements in carburetion, and newness of design.

In both areas, total tractor costs were higher on farms having general-purpose tractors and horses and on farms with tractors alone than on those with standard tractors and horses (table 12). The greater adaptability and use of general-purpose tractors is indicated in table 12. Farmers in Miami County operating with tractors alone used their tractors more than twice as much as those farming with standard tractors and horses. Eighty-five per cent of the tractors on these 13 farms were of the general-purpose type. It should be pointed out that several of the Medina County farms on which no horses were owned were small-scale, part-time farms, inadequately equipped and depending on neighbors' horses for part of their work. This condition accounted for their relatively low use of tractors, which, in turn, increased their hourly cost.

TABLE 12.—Average size of farm, value of tractors, hours of tractor use, and tractor costs on 160 tractor farms grouped according to type of power, two Ohio areas, 1939

Item	Miami County			Medina County		
	Horses and tractors		Tractors alone	Horses and tractors		Tractors alone
	Standard	General-purpose		Standard	General-purpose	
Number of farms	32	45	13	47	11	12
Average per farm:						
Total acres	81	83	80	82	77	67
Crop acres	67	72	70	49	51	33
Value of tractors	$152	$532	$573	$179	$675	$466
Hours of tractor use	150	204	312	133	256	175
Total tractor costs*	$ 65	$115	$132	$ 74	$135	$110
Cost per hour	.43	.56	.42	.56	.53	.63

*Excluding shelter and operator's labor.

The hourly cost of general-purpose two-plow tractors operated less than 200 hours per year was considerably higher than that of standard tractors, but with increased use, the operating cost of the newer, faster tractors compared favorably with that of the older, less adaptable type (table 13).

The operators of small farms of limited tractor use found it more economical to buy an inexpensive secondhand tractor rather than a new one. On farms with available tractor use totaling approximately 300 hours per year, an hour of tractor work with a modern general-purpose two-plow tractor was done at only one-eighth greater cost than an hour of work with an old tractor of the standard type. The greater adaptability, speed, ease of handling, and dependability of the newer tractor would point to its selection over the older type when considerable work is to be done.

TABLE 13.—Relation of hours of annual tractor use to total and hourly costs, 88 standard and 63 general-purpose two-plow tractors, Miami and Medina Counties, Ohio, 1939

Item	Hours of work per tractor, 1939		
	100 or less	101-200	More than 200
Standard two-plow			
Number	23	54	11
Average age, years	13.6	12.8	11.5
Average value	$123	$175	$245
Hours worked	70	144	286
Total tractor costs*	$ 50	$ 72	$120
Cost per hour	.71	.50	.42
General-purpose two-plow			
Number	2	30	31
Average age, years	6.0	4.8	3.4
Average value	$515	$534	$646
Hours worked	79	168	294
Total tractor costs*	$ 89	$109	$138
Cost per hour	1.13	.65	.47

*Excluding shelter and operator's labor.

FARMERS' OPINIONS ON TRACTORS

Reasons for not owning a tractor.—Operators of 51 of the 57 Miami County and 50 of the 65 Medina County farms on which horses were the source of power said that a tractor was unnecessary on their farms. Farmers' reasons for not owning tractors and the number of times each was given were as follows:

	Miami	Medina
Farm is too small	18	16
Investment would be too large	13	15
More equipment would be needed	9	15
Horses must be kept anyway	5	15
Have enough horses to do the work	6	13
Heavy work can be hired more cheaply	14	4
Operating expense would be too great	7	8
Operator is too old	5	9
Horses can work when tractor cannot	1	9

Other reasons mentioned less frequently were: that horses are cheaper, that the operator lacks mechanical ability, that he prefers horses, and that tractors are harder on machines.

Advantage of having a tractor.—The number of times the various advantages of tractor ownership were reported by the 90 Miami County and 70 Medina County farm operators owning tractors were as follows:

	Miami	Medina
Work can be done more seasonably	53	26
Work is made easier for the operator	26	20
More livestock can be kept	33	10
Less labor is required to operate farm	24	15
Number of work horses is reduced	13	13
Work is made easier for horses	11	14
Operator can work more away from farm	11	10
More land can be farmed	11	8

Farmers operating without tractors reported the same advantages, with a different emphasis on some of them, however. Thus, the advantage of being able to operate more land ranked first among those not owning tractors in Miami County and second in Medina County, but in last place with farmers owning them. The difference may be due in part to the fact that the sample probably excluded some formerly small farm operators who enlarged their farming operations after purchasing a tractor, and in part to the probability that not all operators who plan to farm additional land after acquiring a tractor actually do so.

The other advantages of tractor ownership ranked in approximately the same order with both owners and nonowners of tractors. The advantage of being able to perform farm operations more seasonably ranked first in both areas among tractor owners, and first in Medina County and second in Miami County among nonowners. Easier work and the ability to expand the farm business by keeping additional livestock ranked high among the advantages, as did the ability to farm with less labor. In connection with the latter advantage, it must be kept in mind that unless hired labor expense is reduced or unless the labor saved is employed at something which results in an increased income, the principal advantage of tractor ownership along this line will be the fewer and less strenuous days spent in the field by the operator.

EQUIPMENT

EQUIPMENT OWNED

Generally speaking, the larger farms in each area had more machinery than did the smaller farms (appendix table VI). In Miami County, the only tools found on three-fourths or more of the 50-69 – acre farms were grain drills, corn planters, two-horse cultivators, mowers, and wagons. These tools, plus double-disk harrows, grain binders, and manure spreaders, were owned on more than three-fourths of all farms in that area. In Medina County, the only tools found on more than three-fourths of the 50-69 – acre farms were walking plows, spring-tooth and spike-tooth harrows, two-horse cultivators, mowers, and wagons. Additional tools most commonly found on the 90-109 – acre tracts were hay loaders, grain binders, and manure spreaders.

In the Miami County area, there were fewer implements per 100 farms than in Medina County. The farmers in the latter area had more plows, harrows, and other tillage tools, more hay loaders and wagons, but fewer grain drills, corn planters, and manure spreaders.

There was little duplication of machinery in the Miami County area on farms having both horses and tractors as their source of power (appendix table VII). Horse-drawn plows were reduced in numbers when tractor plows were added; single-disk harrows were replaced with double-disk harrows; cultipackers became more common; and two- and three-horse cultivators were replaced by tractor cultivators on farms with general-purpose tractors.

Medina County farmers operating with horses and tractors had more machines than those farming with horses alone. This condition was due in part to some duplication of tools, particularly plows, and in part to the fact that such farmers were more completely equipped with tools, such as drills, corn planters, grain binders, and corn binders. Several of the part-time farmers who were operating with tractors alone in this area were lacking in equipment.

SECONDHAND EQUIPMENT

That farmers are aware of the importance of using secondhand machinery as a means of reducing costs is shown by the fact that nearly two-thirds of the equipment in use on farms in these two areas had been purchased secondhand. The operators of the smaller farms bought more used equipment than did those farming the larger units.

To equip a 75-acre farm with new horse-drawn machinery, exclusive of any small-grain or corn harvesting equipment, would require about $1,300. Satisfactory secondhand equipment could be bought for one-half to one-third that amount. The saving in interest alone, if figured at 6 per cent, would thus amount to $40 or $50 per year, which might, of course, be partially offset by a higher annual repair bill. If the operator has mechanical ability, knows where to look for worn parts on machines, uses good judgment, and makes his purchases in the fall or winter rather than just before spring work begins, he will be able to equip his farm with dependable secondhand tools at relatively low cost.

Farmers changing to general-purpose tractors as their source of power must purchase more of their equipment new, for a few years at least, since secondhand equipment for tractors is not yet available in any supply comparable to that of horse-drawn tools. In Medina County, for instance, where 56 per cent of all the tractors had been purchased as secondhand outfits, only 17 per cent of the general-purpose tractors had been bought secondhand. In the same area, only 8 per cent of the tractor cultivators had been bought secondhand, compared with 63 per cent of the horse-drawn cultivators.

AGE OF EQUIPMENT

The average age of equipment on farms in the Miami County area was 14 years; that in Medina County was 3 years older (table 14). In general, the newest equipment was on farms having horses and all-purpose tractors or tractors alone, and the oldest machinery was on farms operated with horses only.

These present ages seem to indicate that the useful life of farm machinery on farms of this size is greater than 20 years. Some tools, by no means worn out, were no longer used because they had been replaced by other machines or other methods. Horse-drawn plows and cultivators, rendered obsolete by tractor-drawn implements, and grain binders no longer used because of the combine, might be cited as instances of this sort.

BORROWING, EXCHANGING, AND HIRING OF MACHINERY

In each area there was some borrowing, exchanging, or hiring of machinery by farmers not completely equipped with their own machines. The tools most commonly borrowed or exchanged were cultipackers, rollers, grain drills, corn planters, rakes, grain binders, and corn binders. Exchanging of equipment, especially when the machine was accompanied and operated by its owner, was a much more satisfactory arrangement than borrowing.

Some plowing, disking, and grain binding was hired, particularly by farmers not owning tractors. About a third of the farmers in each area hired combines to harvest small grains and soybeans, and the total charge for tractor, combine, and operator ranged from $2.50 to $3.00 per acre. Fewer farmers owned grain drills and corn planters in Medina County, and one-fifth

TABLE 14.—Average age of implements, in years, on farms in Miami and Medina Counties, Ohio, classified as to type of power, January 1, 1940

Implement	Miami County					Medina County				
	Horses only	Horses and tractors		Tractors only	All farms	Horses only	Horses and tractors		Tractors only	All farms
		Standard	General-purpose				Standard	General-purpose		
Tractors										
Standard		12		18	12		13		15	13
General-purpose			4	3	4			2	2	2
Total tractors		12	4	6	7		13	2	8	10
Other machinery										
Plows, horse	16	17	13		16	20	18	21		19
Plows, tractor		10	7	5	7		12	4	7	10
Seedbed tools	16	13	10	10	13	16	16	14	13	15
Drills, planters	19	16	13	11	16	20	19	19	14	19
Cultivators:										
Horse	15	15	14	17	15	20	18	14	17	18
Tractor			4	4	4			2	2	2
Hay tools	18	17	16	12	16	19	20	15	21	19
Grain binders	20	15	18	17	18	23	20	25	21	22
Manure spreaders	15	14	12	12	14	13	14	8	10	12
All others	20	17	18	15	18	20	17	16	23	19
Total other machinery	17	15	12	10	14	19	17	14	14	17
All equipment	17	14	11	9	14	19	17	13	13	17

Source: Date of purchase was reported for approximately 1,400 implements purchased new; data were also secured on the ages of about 800 items, or one-third, of the equipment purchased secondhand.

of the farmers rented them from neighbors, a practice not found in the other area. The prevailing rental charge for either of these tools was 25 to 35 cents per acre.

On these small farms, the cost of hiring a machine was often less than the annual interest charge alone would have been, had the machine been owned by the operator instead of rented. Borrowing and exchanging likewise reduce the size of the machinery investment and possibly the annual machinery cost, but borrowing, exchanging, and hiring do not always provide the needed equipment at the most opportune time.

COOPERATIVE OR JOINT OWNERSHIP OF MACHINERY

Only 13 of the 147 farmers in Miami County and 38 of the 135 in Medina County reported cooperative ownership of some machinery in 1939. Husker-shredders were the machines most frequently owned in this manner in both areas. In Medina County, several farmers owned shares in threshing outfits, silo fillers, and lime spreaders. In Miami County, where there were an increasing use of combines, relatively few silos, and little need of lime, cooperative ownership was confined almost entirely to husker-shredders. In the Medina County area, where the amount of cropland per farm was less than in Miami County and where the proportion of tenant-operated farms was only one-third as large, a few hay tools, corn planters, grain drills, and binders were owned in partnership, ranging from only 2 per cent of the total number of drills to 9 per cent of the total number of corn planters involved.

It might have been expected that more operators of small farms, such as these, would have used cooperative ownership as a means of reducing their equipment investment and operating costs. Practically all those who owned machinery jointly indicated that they were well satisfied with their experience. However, three out of every four not owning any machines in this manner stated that such an arrangement would not be desirable; that they would rather rent or exchange the machines which they might need; that it was cheaper to do this; that they wanted to be independent of other farmers; that trouble would generally arise as to who would use the machine first; and that it was difficult to find neighbors who would take equally good care in the use of machines so owned. Tenant operators in Miami County often cited the possibility of moving out of the neighborhood as a reason for not being able to own any machinery cooperatively.

TOTAL INVESTMENT IN POWER AND MACHINERY

The total investment in power and machinery per farm was smallest on farms operated with horses only, in both areas and in all size-of-farm groups (table 15). Farms with this type of power had horses and machinery with an inventory value amounting to $6.40 for each acre of rotated cropland in the Miami County area, $10.21 per crop acre in Medina County. Farms with standard tractors and horses had a larger investment in power and machinery. The greatest investment was on farms with general-purpose tractors, but these farms had the newest and, therefore, the most dependable, tractors and machinery. Farms in Medina County with general-purpose tractors and horses had a total power and machinery investment amounting to an average of $27.66 per crop acre.

TABLE 15.—Power and machinery investment* in dollars per farm and per crop acre, by size of farm and type of power, 147 Miami and 135 Medina County, Ohio, farms, 1939

Item	Miami County				Medina County			
	Horses only	Horses and tractors		Tractors only	Horses only	Horses and tractors		Tractors only
		Standard	General-purpose			Standard	General-purpose	
50-69 acres								
Investment per farm:								
Horses	161	82	114	.....	159	96	146	.....
Tractors	.....	110	575	586	.....	132	640	513
Machinery	114	151	384	484	158	477	377	257
Total	275	343	1,073	1,070	317	705	1,163	770
Investment per crop acre	6.16	6.56	22.01	20.06	9.38	18.60	26.18	24.68
70-89 acres								
Investment per farm:								
Horses	188	131	154	.....	188	196	167	.....
Tractors	.....	171	501	533	.....	155	663	419
Machinery	203	300	438	488	249	366	797	326
Total	391	602	1,093	1,021	437	717	1,627	745
Investment per crop acre	6.22	9.23	15.15	15.12	10.55	14.92	30.92	21.71
90-109 acres								
Investment per farm:								
Horses	308	161	189	.....	290	206	133	.....
Tractors	.....	120	554	622	.....	244	739	.....
Machinery	271	283	460	706	278	455	571	.....
Total	579	564	1,203	1,328	568	905	1,443	.....
Investment per crop acre	7.26	7.11	14.77	15.62	10.48	16.08	25.25	.....
All farms								
Investment per farm:								
Horses	196	132	160	.....	198	188	150	.....
Tractors	.....	152	532	573	.....	179	675	465
Machinery	181	278	437	554	224	404	582	292
Total	377	562	1,129	1,127	422	771	1,407	758
Investment per crop acre	6.40	8.42	15.72	16.18	10.21	15.61	27.66	23.14

*1939 inventory values, not original cost.

TOTAL COST OF LABOR, POWER, AND MACHINERY

In comparing the total labor, power, and machinery cost of operating farms of a given size with different types of power, it is important that the farms have approximately the same amount of work to be done. Farms differ in their cropping systems and in the intensity of their livestock enterprises. For this reason, farms were sorted on the basis of size in acres, but costs were computed on a per-farm, per-crop acre, and per-man work unit basis (table 16). The latter figure is the most equitable one of the three for determining the relative cost of operating farms with different types of power.

TABLE 16.—Total cost of labor, power, and machinery per farm, per crop acre, and per man work unit, 147 farms, classified by size of farm in acres and by type of power, Miami County, Ohio, 1939

Item	Horses only	Horses and tractors		Tractors only
		Standard	General-purpose	
50-69 acres				
Number of farms	20	4	7	3
Cost per farm:				
Man labor	$405	$441	$426	$296
Horses	129	97	95	.....
Tractor	.....	56	123	119
Machinery*	71	83	113	122
Total	605	677	757	537
Cost per crop acre	13.51	12.95	15.54	10.06
Cost per man work unit	2.94	2.89	3.36	3.22
70-89 acres				
Number of farms	29	21	22	6
Cost per farm:				
Man labor	$464	$477	$451	$464
Horses	168	117	127	.....
Tractor	.....	63	113	119
Machinery*	105	111	142	139
Total	757	768	833	722
Cost per crop acre	12.02	11.77	11.54	10.69
Cost per man work unit	2.80	2.72	2.81	2.32
90-109 acres				
Number of farms	8	7	16	4
Cost per farm:				
Man labor	$583	$496	$462	$424
Horses	239	149	125	.....
Tractor	.....	74	113	124
Machinery*	120	99	132	150
Total	942	818	832	698
Cost per crop acre	11.81	10.31	10.21	8.21
Cost per man work unit	2.94	2.93	2.56	2.14

*Machinery cost includes annual cost of machinery owned plus expenditures for machinery rented and machine work hired.

On the Miami County farms of 50-69 acres, it would appear that tractors alone gave the lowest total cost if the comparison were made on a per-farm or crop acre basis only. Reference to table 4 will show considerably less livestock and fewer man work units on these three part-time farms. In this size group, therefore, lowest cost per unit of work accomplished was not on farms operated with tractors alone, but on farms operated with horses and secondhand standard tractors. The latter group had a total cost amounting to $72 per farm greater than that on farms worked with horses only, but this was more than

offset by the larger number of man work units on the farms with standard tractors. Increased tractor and machinery costs, with only a slight reduction in labor, accounted for the high costs on Miami County farms of 50-69 acres operated with horses and general-purpose tractors.

The same type of power provided the high cost combination on Miami County farms of the next size, those of 70-89 acres. The net increase in cost of operating these farms, as compared with the costs incurred by farms operated with horses or with horses and standard tractors, was not offset by a sufficient increase in amount of available work to lower the cost per man work unit. In this 70-89 – acre group, the lowest costs were obtained on farms not owning horses.

In the next size of farm group (90-109 acres), each succeeding increase in mechanization and decrease in proportion of work done with horses was accompanied by a decrease in total labor, power, and machinery cost per crop acre and per man work unit. On non-tractor farms, the annual cost of keeping four horses was $115 greater than the annual cost of operating a tractor on farms not owning horses but having about the same amount of work to be done; machinery costs per farm were $30 less; but labor cost per farm was $159 greater.

TABLE 17.—Total cost of labor, power, and machinery per farm, per crop acre, and per man work unit, 135 farms classified by size of farm in acres and by type of power, Medina County, Ohio, 1939

Item	Horses only	Horses and tractors		Tractors only
		Standard	General-purpose	
50-69 acres				
Number of farms	22	5	4	6
Cost per farm:				
Man labor	$453	$509	$405	$351
Horses	124	102	111	...
Tractor	...	52	117	101
Machinery*	64	121	111	63
Total	641	784	744	515
Cost per crop acre	19.00	20.69	16.74	16.32
Cost per man work unit	4.10	3.19	3.39	4.40
70-89 acres				
Number of farms	30	28	4	6
Cost per farm:				
Man labor	$491	$523	$479	$441
Horses	138	134	127	...
Tractor	...	68	148	119
Machinery*	92	111	163	96
Total	721	836	917	656
Cost per crop acre	17.40	17.40	17.42	19.09
Cost per man work unit	3.65	3.39	3.46	4.33
90-109 acres				
Number of farms	13	14	3	...
Cost per farm:				
Man labor	$543	$492	$573	...
Horses	146	131	129	...
Tractor	...	95	144	...
Machinery*	105	134	157	...
Total	794	852	1,003	...
Cost per crop acre	14.65	15.13	17.54	...
Cost per man work unit	3.41	3.13	2.94	...

*Machinery cost includes annual cost of machinery owned plus expenditures for machinery rented and machine work hired.

In Medina County, a combination of horses and standard tractors provided the lowest operating cost per man work unit on farms of less than 90 acres (table 17). The tractor and horses together cost more per farm than horses alone, but the increased costs were more than offset by the larger amount of work done, as shown in table 4. Farms operated with tractors alone were not typical of other farms in the same size groups in that they had less cropland and less livestock. Thus, their costs per unit of work accomplished were high.

On the Medina County farms of 90 to 109 acres, total costs were increased in shifting from horses alone to horses and standard tractors, and again in shifting to horses and general-purpose tractors, but with each successive shift toward increased mechanization, more work was done and lower costs per man work unit resulted.

A COMPARISON OF MATCHED FARMS

Another method of studying comparative costs of operating with different sources of power is to select matched farms. Matching of farms was very difficult, however; some would be nearly identical in their cropping patterns but would vary considerably in their livestock and hence not be alike in total amount of work done.

Five Miami County farms operated with horses were matched with five others operated with tractors only (table 18). This comparison again shows a lower cost for the latter type of power. The investment in power and machinery was considerably greater on the farms operated with tractors; but there was a saving of $40 in labor, and the cost of operating the tractor and the additional machinery expense on the tractor-operated farms amounted to $82 less than the cost of keeping horses. Additional credit could be given to the tractor for its ability to get the work done at the most opportune time.

TABLE 18.—Investment and cost of operation with horses and with tractor on similar farms having 72 acres of cropland and 20 animal units of livestock, Miami County, Ohio, 1939

Item	Type of power	
	Horses only	Tractor only
Number of farms	5	5
Per farm:		
Total acres	86	82
Acres of cropland	72	72
Productive animal units	20	20
Number of work horses	3.8	.....
Total man work units	333	344
Investment:		
Horses	$243	.....
Tractor	.....	$ 583
Machinery	310	466
Total	553	1,049
Cost:		
Labor	497	457
Horses	230	.....
Tractor	.....	122
Machinery	63	89
Machine hire	44	44
Total	834	712

FURTHER CONSIDERATIONS IN ADJUSTING POWER TO FARM NEEDS

So far in this study, labor, power, and machinery costs have been given for groups of farms and total and average costs indicated. In many of these comparisons, however, circumstances have been present that make difficult a direct application of these averages to the individual farm. Horses, tractors, and machinery were of varying ages and values. Because of the small number of hours that many tractors were used annually, the life of these tractors was difficult to estimate. Thus, although a tractor used 500 hours annually might reasonably be expected to give 8,000 hours of useful service, it could hardly be expected that one used 200 hours annually would last 40 years. Even so, the life of new tractors on some of the smaller farms was probably underestimated. On many farms, family labor was used simply because it was available, although it may not have been necessary in the operation of the farm. Little information was secured regarding the monetary advantages of getting the field work done at the most opportune time, an advantage which is especially significant in wet, backward seasons.

To illustrate further a method of comparing alternative ways of equipping a farm with power and machinery, a Miami County farm of 75 acres was selected. This farm was operated with three horses prior to 1939. There were 67 acres of rotated cropland consisting of 20 acres of corn, 19 acres of oats, 12 acres of alfalfa hay, and 16 acres of rotation pasture. The operator kept 8 milk cows, 5 brood sows, and 150 hens. The only labor, in addition to that of the operator, was 1.5 months of family labor.

Three alternative methods of equipping this farm will be considered and the advantages and disadvantages of each analyzed. The first method is to equip it with three 6-year-old horses and new horse-drawn machinery; the second method is to equip it with a new one-plow tractor and tractor machinery; and the third, to purchase a new one-plow tractor, two horses, and adequate new machinery for this type of power. The total investment in machinery and power with three 6-year-old horses would be $1,673; with a one-plow tractor, approximately $2,085; and with two 6-year-old horses and a one-plow tractor, $2,295 (table 19).

TABLE 19.—Investment in new machinery for operating a 75-acre farm with horses only, a general-purpose tractor, or horses and a one-plow general-purpose tractor, in dollars

Item	As operated	Alternatives	
	Horses only	Tractor	Horses and tractor
Horses, three 6-year-old	375		
Horses, two 6-year-old			250
Tractor, one-plow		650	650
Sulky plow, one-bottom, 14-inch	70		
Tractor plow, one-bottom, 14-inch		90	90
Disk harrow, 6-foot, single	70	70	70
Spring-tooth, 8-foot	45	45	45
Spike-tooth, two sections	25	25	25
Grain drill	190	190	190
Corn planter	120	160	120
Cultivator	68	125	125
Mower, 5-foot	120	140	140
Side-delivery rake	130	130	130
Loader	180	180	180
Manure spreader	180	180	180
Wagon	100	100	100
Total	1,673	2,085	2,295

All the field work could be done with three horses in a normal year. In the alternative, which includes both horses and a tractor, it is assumed that the heavy work and the cultivating would be done with the tractor and that corn planting, haying, and light hauling would be done with horses. In all cases, the small grain would be combined by a custom outfit.

Turning at once to the costs of operating the farm, it will be noted that the operating outlay is less for the method using a tractor alone than where horses are used (table 20). The overhead costs are higher for the methods using tractor power and highest where both horses and a tractor are used.

TABLE 20.—Costs of operating a 75-acre farm with three horses only, a general-purpose tractor only, or a general-purpose tractor and two horses

Costs	As operated		Alternatives			
	Horses only		Tractor only		Tractor and horses	
	Amount	Dollars	Amount	Dollars	Amount	Dollars
Operating						
Grain*	4,950 pounds	52			3,400 pounds	34
Roughage*	9.6 tons	74			7 tons	55
Miscellaneous		6				4
Fuel			425 gallons	47	250 gallons	28
Oil			45 quarts	7	28 quarts	4
Repairs, machinery, and tractor		48		61		57
Machine work hired		48		48		48
Total		228		163		230
Overhead						
Depreciation:						
Horses, 8 years		48				32
Tractor†				36		27
Machinery, 20 years		65		72		70
Interest						
Horses		9				7
Tractor				16		16
Machinery		32		36		35
Insurance and taxes						
Horses		6				4
Tractor				10		10
Machinery		19		22		21
Total		179		192		222
Total annual cost		407		355		452

*Valued at average farm sales prices, Ohio, 1930-1939.
†Life of tractor estimated to range from 15 years @ 600 hours per year to 25 years @ 200 hours per year.

The machinery costs are also greater on tractor farms because of the higher first cost of many tractor-drawn machines. Where both horses and a tractor are kept, the operating expense is about the same as where horses alone are used, but the overhead cost is greater. Thus, with this method, low annual costs can be obtained only by using secondhand tractors and machinery and old horses. Where either the tractor or horses are old and unreliable, the two kinds of power may be very desirable to lessen the risk from delayed farm work.

Time required to do the field work.—One advantage which accrues to operators using tractors is that of being able to do the field work in a shorter time than is possible with horses and thus avoiding delays in planting and harvesting due to rainy weather. The estimated number of days required to do the

field work with the tractor and with horses is given in table 21. Fifty days would be required to do the work with horses, and the same work could be done with a one-plow tractor in 31 days, or in nearly 40 per cent less time. The time saved would be available for work off the farm, for operating a larger unit, for taking care of more livestock, or for leisure.

TABLE 21.—Estimated days of operator's labor required for the field work on a 75-acre farm in Miami County, Ohio, operated with horses or with a one-plow tractor

Crop	Acres	Operation	Power used					
			Horses only			Tractor only		
			A day's work*	Times over	Days required	A day's work	Times over	Days required
			Acres	*Number*	*Number*	*Acres*	*Number*	*Number*
Corn	20	Plowing	2	1	10	4	1	5
		Disking and dragging	7	1	3	15	1	1.5
		Cultipacking and dragging	8	1	2.5	15	1	1.5
		Planting	10	1	2	15	1	1.5
		Cultivating	6.5	3	9.5	10	3	6
Oats	19	Disking	7	2	6	15	2	2.5
		Planting	10	1	2	15	1	1.2
		Combining	8	1	2.5	8	1	2.5
Hay	12	Mowing	7.5	3	5	15	3	2.5
		Raking	15	3	3	22	3	2
		Hauling	7	3	5	7	3	5
Total—all operations†					50.5			31.2

*The Ohio State University, Department of Rural Economics Mimeograph Bulletin No. 32.

†Excluding hauling manure and husking corn from standing stalks.

The optimum seasonal distribution of the field work is shown in table 22. The number of days required for completing the field operations with horses and with a tractor is shown by 10-day periods. The number of days required in each 10-day period is then compared with the probable number of days available for field work.

In normal years, horse farmers may be delayed from getting their work done at the optimum time an average of 2 days by the middle of April, but they would be able to catch up by the end of the month. This delay would not make any very noticeable difference in crop yields.[5] However, it is probable that in at least 1 year in 6, the farmer operating with horses would be 10 days late with his field work. Such a delay would have very decided effects on crop yields. The tractor operator should have ample time for field work, even in such wet seasons. Drilling and planting cannot be done satisfactorily in many areas if a hard rain has fallen after the ground has been prepared. After a rain, it is necessary to disk and harrow the ground again before planting or drilling. Hence, it is a practice among many farmers to prepare and immediately plant a part of the acreage to be put in oats or corn rather than delay planting until the entire seedbed is ready.

Loss resulting from delays.—There are definite advantages in getting the field work done within relatively short periods. Decreases in yields of crops may result from delays in completing certain field operations within these

[5]The plowing indicated for March in table 22 is often done in late fall or early winter.

TABLE 22.—Estimated number of days of field work on 75-acre farm, operated with horses or with tractor, and days available in average season and in short seasons, Miami County, Ohio

Dates	Days required for field work* with horses (H) or with tractor (T)								Days available†	
	Corn 20 acres		Oats 19 acres		Hay 12 acres		Total		Average season‡	1 year in six§
	H	*T*	*H*	*T*	*H*	*T*	*H*	*T*		
March 1-10	2.5	.....	.....	.....	.....	.....	2.5	.....	3.7	0.6
11-20	2.5	.....	.....	.....	.....	.....	2.5	.....	3.7	.6
21-31	5.0	5.0	.....	.....	.....	.....	5.0	5.0	3.7	.6
April 1-10	.....	.....	6.0	2.5	.....	.....	6.0	2.5	4.9	3.3
11-20	3.0	1.5	2.0	1.2	.....	.....	5.0	2.7	4.9	3.3
21-30	2.5	1.5	.....	.....	.....	.....	2.5	1.5	5.0	3.3
May 1-10	2.0	1.5	.....	.....	.....	.....	2.0	1.5	5.1	3.6
11-20	3.5	2.5	.....	.....	.....	.....	3.5	2.5	5.1	3.7
21-31	.....	.....	.....	.....	.....	.....	.....	.....	5.1	3.7
June 1-10	3.0	1.8	.....	.....	1.6	.9	4.6	2.7	5.7	4.6
11-20	.....	.....	.....	.....	3.4	3.0	3.4	3.0	5.8	4.7
21-30	3.0	1.7	.....	.....	.....	.....	3.0	1.7	5.8	4.7
July 1-10	.....	.....	.....	.....	.....	.....	.....	.....	6.4	5.2
11-20	.....	.....	2.5	2.5	.....	.....	2.5	2.5	6.5	5.3
21-31	.....	.....	.....	.....	4.2	3.0	4.2	3.0	6.5	5.3
August 1-10	.....	.....	.....	.....	.....	.....	.....	.....	6.3	5.0
11-20	.....	.....	.....	.....	.....	.....	.....	.....	6.3	5.0
21-31	.....	.....	.....	.....	.....	.....	.....	.....	6.2	4.9
September 1-10	.....	.....	.....	.....	3.8	2.6	3.8	2.6	5.1	2.4
11-20	.....	.....	.....	.....	.....	.....	.....	.....	5.0	2.4
21-30	.....	.....	.....	.....	.....	.....	.....	.....	5.0	2.3
Total	27.0	15.5	10.5	6.2	13.0	9.5	50.5	31.2	111.8	74.5

*Does not include hauling manure and husking corn from standing stalks.
†Excluding Sundays.
‡Estimated that 0.3 inch of rain would delay ordinary field work 1 day. Seasonal differences in rate of evaporation were taken into account.
§Average rainfall plus standard deviation, in inches, divided by 0.3 and corrected for differences in evaporation rate.

optimum periods. The loss in yield from delaying the drilling of oats 9 days beyond the optimum planting period is 23 per cent (table 23). A similar loss occurs where haying is delayed to such an extent that only two cuttings instead of three can be obtained. This loss does not take into consideration the poorer quality of hay which would result.

TABLE 23.—Average loss in crop yields from delaying selected operations, Ohio

Operation	Delay	Yield at optimum	Yield after delay	Loss
	Days	*Bushels*	*Bushels*	*Per cent*
Planting corn	10	65.2	63.7	2
Planting corn	10	63.7	57.8	9
Drilling oats	9	57.1	43.9	23
Drilling oats	12	43.9	33.8	23
Plowing for wheat	15	37.7	36.9	2
Plowing for wheat	15	36.9	34.9	5
Sowing wheat	16	34.1	28.5	16
Sowing wheat (8 days later)	16	32.7	26.3	20
Planting soybeans	12	22.3	20.4	9
Three cuttings of alfalfa	.....	8,870 pounds	.....	.....
Two cuttings of alfalfa	.....	.....	6,850 pounds	23*

Source: Handbook of Experiments in Agronomy, Special Circular No. 53, Ohio Agricultural Experiment Station, Wooster, Ohio, September 1938.
*The percentage of leaves decreased from 43.9 per cent to 38.5 per cent, and the protein content decreased from 17.0 per cent to 15.6 per cent.

Undoubtedly these losses would be pyramided, since once a farmer gets behind with his work, he will be late in much of the work that follows. If he is late in planting his oats, he may also be late in preparing the ground for corn and in planting it. If his corn is late, then cultivating and haying will conflict, and perhaps haying and grain harvesting. In the fall, corn cutting may hold back wheat sowing if wheat is sown in the corn stubble.

If the physical losses shown in table 24 are encountered on this farm because of delayed field work, the monetary loss will approximate $25 per year, at 1930-1939 average prices. This loss appears to be a conservative estimate, since grain and hay are usually highest in price in years when a shortage of feed occurs. In the next section, the annual value of this produce is added to costs on the horse-operated farm as income foregone because of delayed field operations.

TABLE 24.—Monetary loss in income from delay of 10 days in field operations on a 75-acre farm, Miami County, Ohio

Operations delayed 10 days	Normal yield	Resultant loss in yield		Total loss for 6-year period		
	Per acre	*Per cent*	*Per acre*	*Amount*	*Price**	*Value*
Drilling oats	40 bushels	20	8 bushels	152 bushels	$0.33	$ 50
Planting corn	72 bushels	6	4 bushels	80 bushels	.59	47
Cutting hay	2.5 tons	20	.5 ton	6 tons	8.61	52
Total loss						$149
Total annual loss†						$ 25

*Average Ohio farm prices, 1930-1939.
†Loss occurs once every 6 years.

Net operating costs.—No labor would be hired in any of the three alternatives. Other costs of operating the farm include: feed, fuel, oil, and repair costs and the expense for combining, all of which must be met within the year, and overhead costs, including depreciation, interest, insurance, and taxes, which can be postponed temporarily. Credits for manure produced by horses are deducted to obtain a comparable net operating cost for the three types of power.

TABLE 25.—Net operating costs, in dollars, on a 75-acre farm operated with horses, a tractor, or a combination of both, Miami County, Ohio

Item	Horses only	Tractor only	Tractor and horses
Debits			
Operating expense	228	163	230
Overhead expense	179	192	222
Loss from delayed field work	25	.....	.....
Total	432	355	452
Credits			
Manure	18	.....	12
Net operating costs	414	355	440

The computations in table 25 indicate that the net costs would be lower on the farm operated with a tractor than if horses were used—$355 as compared with $414. This computation is from the standpoint of annual costs, and it

must be recognized that the organization for tractor operation includes an investment over a longer period of time; that is, the tractor will not be worn out for 15 to 25 years, whereas the horses will need to be replaced within 10 years or less. The computation does not include a consideration for the time available to the operator using a tractor for work off the farm. He would have an advantage of at least 19 working days in this respect.

Computations similar to those in table 25 are given in table 26 for a 60-acre farm and in table 27 for a 90-acre farm. On the 60-acre farm, a tractor would lead to practically the same machinery and power cost as horses, but with a tractor, additional time would be available for work off the farm. In fact, there are a large number of part-time farmers who are operating small farms with tractors and working at full-time jobs off the farm. These families find that living costs are less on the farm and that the field work can be done in the evenings and on holidays.

TABLE 26.—Costs of operating a 60-acre farm with two horses only, a general-purpose tractor only, or a general-purpose tractor and two horses

Item	As operated		Alternatives			
	Horses only		Tractor only		Tractor and horses	
	Amount	*Dollars*	*Amount*	*Dollars*	*Amount*	*Dollars*
Operating*						
Grain	3,630 pounds	38			3,400 pounds	34
Roughage	7 tons	55			7 tons	55
Miscellaneous		4				4
Fuel			340 gallons	37	200 gallons	22
Oil			36 quarts	5	22 quarts	3
Repairs		45		56		53
Machine work hired		38		38		38
Total		180		136		209
Overhead						
Depreciation:						
Horses		32				32
Tractor				33		24
Machinery		58		65		63
Interest:						
Horses		7				7
Tractor				16		16
Machinery		32		36		35
Insurance and taxes:						
Horses		4				4
Tractor				10		10
Machinery		19		22		21
Total		152		182		212
Total annual cost		332		318		421
Less manure credit		12				12
Net operating cost		320		318		409

*Excludes charge for shelter and operator's labor for repairs, feeding, and care.

On small farms equipped with both horses and tractor, the duplication of power leads to high net operating costs, especially on the 60-acre farm.

Of particular interest is a comparison between the alternatives using horses only and both horses and a tractor on larger farms. In moving from the 60-acre to the 90-acre farm, when either a third horse or a tractor is needed, it is found that the costs of operating the 90-acre farm with a two-horse team and a tractor are only slightly higher than the cost would be if the extra horse had been used.

TABLE 27.—Costs of operating a 90-acre farm with three horses only, a general-purpose tractor only, or a general-purpose tractor and two horses

Item	As operated		Alternatives			
	Horses only		Tractor only		Tractor and horses	
	Amount	*Dollars*	*Amount*	*Dollars*	*Amount*	*Dollars*
Operating*						
Grain	5,450 pounds	57			3,400 pounds	34
Roughage	10.5 tons	81			7 tons	55
Miscellaneous		6				4
Fuel			510 gallons	56	300 gallons	33
Oil			54 quarts	8	33 quarts	5
Repairs		51		66		61
Machine work hired		58		58		58
Total		253		188		250
Overhead						
Depreciation:						
Horses		48				32
Tractor				39		30
Machinery		71		79		77
Interest:						
Horses		9				7
Tractor				16		16
Machinery		32		36		35
Insurance and taxes:						
Horses		6				4
Tractor				10		10
Machinery		19		22		21
Total		185		202		232
Loss from delayed field work		30				
Total annual cost		468		390		482
Less manure credit		18				12
Net operating cost		450		390		470

*Excludes charge for shelter and operator's labor for repairs, feeding, and care.

The analysis of the alternatives available on these farms has shown that the year-to-year operating costs would be less when a tractor furnished the power than when either horses alone or horses and a tractor were used, except that the small farm of 60 acres may be operated about as cheaply with horses as with a new tractor. It should also be pointed out that when a small farm is equipped with both tractor and horses, the operating costs are higher than if it is handled either by horses or tractor alone. However, on farms of 90 acres or more, the cost of the horse-and-tractor combination may not be greatly in excess of the cost of operating with horses alone.

SUMMARY AND CONCLUSIONS

Farmers can operate small farms with one-plow or secondhand tractors as cheaply as with horses. In addition, many opportunities for additional income are made available to those who have tractors. The field work can be done more quickly, and work off the farm can be done for extra cash income. Crops can be cared for at the optimum time, and maximum yields can be secured. More livestock can be kept, for the horses can be replaced with productive livestock.

It appears that the chief reason for not purchasing and using a tractor is lack of capital or reluctance to invest a large sum in such a durable machine. The problem is akin to that of installment buying, which is done because it is easier to raise a series of small amounts of cash than a large lump sum even though the total amount spent is greater. Tractor operation requires cash for fuel and oil and a relatively large investment. The feed for horses can be grown on the farm. However, in most cases, the income which could be obtained by feeding a like amount to productive livestock would be more than enough to purchase the fuel, oil, and repairs necessary for a tractor.

Small differences were found in the amounts of man labor on farms using different types of power in Miami and Medina Counties. In Miami County, there was an average of only 0.2 man per farm more on the horse farms than on farms using tractors exclusively. It is probable that many farmers used some family labor because it was available, although it was more than was needed to operate the farm. Although there was little reduction in total labor, more livestock was kept, more cropland was handled, and hence more work was accomplished per man with each successive step in the mechanization of these farms.

In neither area did small farms operated with horses and general-purpose tractors tend to keep fewer work horses than those operated with horses and standard tractors. The operators continued to keep a two-horse team for planting corn, haying, hauling manure, and other light work. No advantage was taken of the opportunities for feeding horses less heavily on farms where the heavy work was done with tractors. Very few colts were raised, owing to the poor market for horses.

An important observation was that a large percentage of the tractors were purchased secondhand. The availability of these secondhand tractors, which could be bought for considerably less than half the price of new tractors, made it possible for operators of small farms to equip their farms at low cost and still maintain low operating expenses. Many farmers were able to have both horses and a tractor with no larger total investment and with a smaller total annual expense than would have been required for young horses alone.

TABLE 28.—Economic advantages and disadvantages of operating a small farm with a tractor or with horses

Tractor	Horses
Advantages:	Disadvantages:
Lower total costs of operation, except on farms of 60 acres or less	Higher total costs of operation
Expenses for fuel and oil generally less than value of feed for horses	Value of feed for horses generally greater than cash expense for fuel and oil for tractor
Risk of losing investment small; repairs small part of total investment	Risk of losing investment great through possible death of horses
Feed formerly fed to horses available for additional livestock, thus enlarging business	Feed required for horses decreases amount of productive livestock which can be kept
Work can be done more quickly, allowing for work off the farm or operation of a larger unit	Size of business limited by the longer time required to perform a given amount of work
Field work can be completed at optimum time in spite of adverse weather conditions	Field work may be delayed by adverse weather conditions, resulting in lower yields
Disadvantages:	Advantages:
High initial investment for tractor and machinery	Low initial investment for horses and machinery
Requires cash to purchase fuel and oil	Low cash requirement

Few farmers availed themselves of the opportunity to reduce their machinery investment through joint or cooperative ownership of equipment. Nearly two-thirds of all the field machinery in use had been purchased secondhand. In general, a larger machinery investment was needed on tractor farms, because most tractor machines cost more than horse-drawn machines, and secondhand tractor machinery was not generally available. The cost of maintaining this higher investment was largely offset by lower costs of operating the tractors, especially on farms of 80 acres or more. The farm value of the horse feed was usually higher than the cash cost of the tractor fuel and oil.

It may be said that on most small farms, the long-time average costs of operating with a tractor are no greater than those of operating with horses. The use of a tractor, if wisely combined with the equipment already on a farm, need not cost any more over a period of years than the use of horses, and where any considerable amount of work is to be done, can easily be cheaper. It has the disadvantage, where capital is scarce, of requiring a larger investment. Also, some cash is needed for fuel, whereas most farmers with horses can produce their own horse feed.

APPENDIX

METHODS USED IN COMPUTING COSTS

Man labor.—Hired labor was figured at cost, as reported by individual farmers. The labor of the operator was valued at $400 per year; family labor was charged at the same rate, after conversion to a man-equivalent basis by use of the following factors:

1 boy 18 years old = 1 man
1 boy 15 years old = ¾ man
1 boy 12 years old = ½ man

Tractors.—The quantity and cost of fuel and oil and the amount spent for repairs were reported by the operator. Other tractor costs were computed as follows:

Depreciation=year 1940 minus year of purchase plus years of future use divided into the purchase price paid by the farmer

Inventory value=purchase price of tractor minus (depreciation per year × age in 1939)

Interest on investment=5 per cent of the inventory value of the tractor

Taxes and insurance=1.5 per cent of the inventory value of the tractor

Machinery.—

Life=estimated at 20 years

Depreciation=5 per cent of the purchase price

Inventory value=purchase price minus (annual depreciation × age of the machine up to and including 19 years)

Interest on investment=5 per cent of the inventory value

Repairs, taxes, and insurance=5 per cent of the inventory value of the machinery

Horses.—In computing the cost of horse feed, the quantities of which were reported by farmers, the 1930-1939 average Ohio farm prices were used. Corn was valued at 59 cents per bushel, oats at 33 cents per bushel, hay at $8.61 per ton, straw and stover at one-third the value of hay.

Depreciation on horses was derived by use of data in appendix table I. The annual depreciation figure given in column VI includes the element of risk for horses at a given age, since all horses do not reach the maximum age reported here.

TABLE I.—Estimated average life expectancy and annual depreciation charges for horses, Medina and Miami Counties, 1939

Age	Estimated average life	Estimated life expectancy	Relative value	Estimated value	Estimated annual depreciation
I	II	III	IV	V	VI
Years	*Years*	*Years*	*Per cent*	*Dollars*	*Dollars*
3	12.6	9.6	85	106.25	11
4	12.8	8.8	95	118.75	13
5	13.1	8.1	100	125.00	15
6	13.4	7.4	100	125.00	16
7	13.8	6.8	95	118.75	17
8	14 3	6.3	90	112.50	17
9	14.8	5.8	85	106.25	17
10	15.4	5.4	80	100.00	18
11	16.0	5.0	72	90.00	17
12	16.6	4.6	65	81.25	17
13	17.3	4.3	57	71.25	15
14	18.0	4.0	50	62.50	14
15	18.7	3.7	43	53.75	13
16	19.5	3.5	35	43.75	11
17	20.3	3.3	30	37.50	10
18	21.1	3.1	25	31.25	8
19	21.9	2.9	21	26.25	7
20	22.8	2.8	18	22.50	6
21	23.6	2.6	15	18.75	5
22	24.5	2.5	13	16.25	5
23	25.3	2.3	11	13.75	4
24	26.1	2.1	9	11.25	3
25	26.8	1.8	7.5	9.38	2
26	27.6	1.6	6.5	8.12	2
27	28.3	1.3	5.5	6.88	1
28	28.9	.9	4.5	5.62	1
29	29.5	.5	4.1	5.12	.....
30	30.0	.....	4.0	5.00	.....

II Derived from column I and data on ages of horses in both counties. Example: At 10 years of age, a horse is expected to live to be 15.4 years of age, the average age of all horses in both areas 10 years old or older.

III The difference between columns I and II.

IV Estimated from data obtained from Farm Security Administration.

V The full value of $125 is the average of the values placed on 53 work horses 5 and 6 years old by farm operators in both areas.

VI Column V minus a $5 credit for hide and carcass, divided by column III and rounded.

TABLE II.—Number of farms, grouped according to type of power and size in acres, having specified number of months of man labor, Miami and Medina Counties, 1939

Size of farm and total months of labor	Number of farms by type of power							
	Miami County				Medina County			
	Horses only	Horses and tractors		Tractors only	Horses only	Horses and tractors		Tractors only
		Standard	General-purpose			Standard	General-purpose	
50-69 acres								
0.1- 6.0	2				1			1
6.1-12.0	3	1	3	3	3	1	2	2
12.1-18.0	14	3	4		16	2	2	3
18.1-24.0	1				2	2		
24.1-30.0								
Total	20	4	7	3	22	5	4	6
70-89 acres								
0.1- 6.0			1					
6.1-12.0	5	3	3	1	9	5		1
12.1-18.0	21	16	17	5	16	17	4	5
18.1-24.0	2	1	1		4	5		
24.1-30.0	1	1			1	1		
Total	29	21	22	6	30	28	4	6
90-109 acres								
0.1- 6.0								
6.1-12.0			1	2	2	3		
12.1-18.0	5	7	15	2	8	9	2	
18.1-24.0	2				1	2		
24.1-30.0	1				2		1	
Total	8	7	16	4	13	14	3	

TABLE III.—Number of farms, grouped by size in acres and by type of power, having specified number of horses, Miami and Medina Counties, Ohio, 1939

Size of farm and number of horses	Number of farms by type of power					
	Miami County			Medina County		
	Horses only	Horses and tractors		Horses only	Horses and tractors	
		Standard	General-purpose		Standard	General-purpose
50-69 acres						
One horse	.....	1	1	.....	.....	1
Two horses	12	3	5	18	5	3
Three horses	6	.....	1	4	.....	.....
Four horses	2	.....	.....	.....	.....	.....
Five horses	.....	.....	.....	.....	.....	.....
Total	20	4	7	22	5	4
70-89 acres						
One horse	.....	.....	.....	.....	.....	.....
Two horses	7	18	19	22	21	3
Three horses	16	3	3	7	7	.....
Four horses	6	.....	.....	1	.....	1
Five horses	.....	.....	.....	.....	.....	.....
Total	29	21	22	30	28	4
90-109 acres						
One horse	.....	.....	.....	.....	.....	.....
Two horses	.....	5	13	7	13	2
Three horses	2	1	3	5	.....	1
Four horses	4	1	.....	1	1	.....
Five horses	2	.....	.....	.....	.....	.....
Total	8	7	16	13	14	3

TABLE IV.—Percentage of drawbar work done by tractors, on farms grouped according to size in acres, Miami and Medina Counties, Ohio, 1939*

Operation	Miami County				Medina County			
	50-69 acres	70-89 acres	90-109 acres	All farms	50-69 acres	70-89 acres	90-109 acres	All farms
Plowing	56	72	76	71	40	46	57	48
Disking	58	72	80	72	55	64	63	63
Cultipacking	62	62	65	63	15	17	24	19
Harrowing	29	27	35	29	34	36	34	35
Planting corn	17	10	8	11	23	4	0	7
Cultivating	31	49	62	50	22	9	21	15
Drilling grain	18	10	18	13	16	5	4	7
Mowing	4	8	14	9	16	4	4	6
Cutting grain	56	63	63	62	43	47	41	44
Binding corn	20	38	24	31	33	17	8	18
Other drawbar†	2	6	12	7	18	9	1	9
Total drawbar	27	35	41	35	27	24	24	25

*Includes work done with operator's tractor, hired and exchange tractor work.

†Excludes combining but includes other work of harvesting corn, small grains, and hay, hauling manure and other hauling.

TABLE V.—Percentage of drawbar work done by tractors on farms grouped according to type of power, Miami and Medina Counties, Ohio, 1939*

Operation	Miami County					Medina County				
	Horses only	Horses and tractors		Tractors only	All farms	Horses only	Horses and tractors		Tractors only	All farms
		Standard	General-purpose				Standard	General-purpose		
Plowing	13	96	99	100	71	3	79	84	100	48
Disking	20	99	100	100	72	11	93	93	100	63
Cultipacking	9	74	100	100	63	1	21	76	89	19
Harrowing	0	41	85	100	29	0	64	67	99	35
Planting corn	0	0	1	94	11	0	0	18	65	7
Cultivating	1	32	93	100	50	0	0	70	88	15
Drilling grain	0	0	13	100	13	0	3	32	47	7
Mowing	0	3	3	89	9	0	3	20	66	6
Cutting grain	7	90	100	100	62	12	68	75	93	44
Binding corn	0	16	42	83	31	0	25	16	100	18
Other drawbar†	0	1	3	67	7	0	4	20	84	9
Total drawbar	5	41	50	87	35	2	35	52	87	25

*Includes work done with operator's tractor, hired and exchange tractor work.
†Excludes combining, but includes other work of harvesting corn, small grains, and hay, hauling manure, and other hauling.

TABLE VI.—Number of implements per 100 farms, 147 Miami County and 135 Medina County, Ohio, farms grouped according to size in acres, January 1, 1940

Implement	Miami County				Medina County			
	50-69 acres	70-89 acres	90-109 acres	All farms	50-69 acres	70-89 acres	90-109 acres	All farms
Tractors, standard	15	30	20	24	19	46	47	39
Tractors, general-purpose	29	33	54	37	22	10	10	13
Walking plows	62	54	46	54	78	84	87	83
Sulky plows	29	32	20	29	27	41	33	36
Tractor plows	44	62	74	60	39	50	57	49
Single-disk harrows	44	18	3	20	24	40	47	37
Double-disk harrows	47	79	91	75	18	37	43	33
Rollers	32	15	9	18	39	41	47	41
Cultipackers	35	41	71	47	24	37	30	32
Spring-tooth harrows	38	38	40	39	80	94	93	90
Spike-tooth harrows	53	77	74	71	84	78	83	81
Grain drills	85	93	94	91	51	76	67	68
Corn planters	82	97	94	93	46	56	62	54
Weeders	3	5	3	4	8	6	7	7
Rotary hoes	3	6	9	5	0	3	3	2
One-horse cultivators	9	3	0	3	32	18	33	25
Two-horse cultivators	79	76	69	75	86	97	97	94
Three-horse cultivators	0	19	26	16	...	...	...	...
Tractor cultivators	26	29	49	33	16	4	10	9
Mowers	91	96	97	95	93	96	100	96
Tedders	3	8	9	7	12	28	10	20
Dump rakes	69	71	80	73	42	43	35	41
Side-delivery rakes	3	4	9	5	27	28	48	32
Hay loaders	12	17	34	20	62	75	82	73
Grain binders	59	79	84	76	62	77	83	74
Combines	3	1	3	2	0	1	0	1
Corn binders	15	29	40	29	12	40	23	29
Corn pickers	0	1	0	1	0	0	0	0
Husker-shredders	3	5	13	7	6	10	8	9
Ensilage cutters	3	0	3	1	2	8	4	5
Potato planters	3	0	7	2	9	15	12	13
Potato diggers	0	0	3	1	7	6	10	7
Manure spreaders	71	92	94	88	54	75	75	69
Wagons	94	99	109	100	132	137	130	134
Total	1,144	1,307	1,431	1,300	1,213	1,457	1,476	1,395

TABLE VII.—Number of implements per 100 farms, 147 Miami and 135 Medina County, Ohio, farms grouped according to type of power, January 1, 1940

Implement	Miami County				Medina County			
	Horses only	Horses and tractors		Tractors only	Horses only	Horses and tractors		Tractors only
		Standard	General-purpose			Standard	General-purpose	
Tractors, standard	.....	100	2	15	.....	102	.....	42
Tractors, general-purpose	.....	.....	97	89	.....	.....	100	58
Walking plows	81	56	33	.....	92	89	64	25
Sulky plows	60	16	7	.....	55	10	18	.....
Tractor plows	.....	100	96	100	.....	90	100	100
Single-disk harrows	49	.....	4	.....	52	21	27	8
Double-disk harrows	47	100	87	92	9	61	45	58
Rollers	30	16	4	15	48	41	36	17
Cultipackers	23	44	69	77	25	34	55	42
Spring-tooth harrows	49	25	40	23	91	95	82	75
Spike-tooth harrows	63	75	72	92	74	87	82	92
Grain drills	88	97	89	100	66	71	91	37
Corn planters	91	94	91	100	54	56	73	33
Weeders	7	3	2	.....	8	9	.....	.....
Rotary hoes	2	.....	13	8	3	.....	9	.....
One-horse cultivators	5	3	2	.....	25	36	.....	8
Two-horse cultivators	100	88	47	8	101	100	82	42
Three-horse cultivators	16	34	7	8	.....	.....	.....	.....
Tractor cultivators	.....	3	80	92	.....	.....	55	50
Mowers	98	97	96	85	97	99	100	75
Tedders	7	9	4	8	15	29	27	.....
Dump rakes	81	78	71	39	44	41	27	33
Side-delivery rakes	.....	3	7	23	35	34	36	8
Hay loaders	21	16	13	46	72	81	82	42
Grain binders	77	78	82	54	69	86	82	50
Combines	.....	.....	.....	23	.....	.....	9	.....
Corn binders	26	34	33	39	23	35	45	17
Corn pickers	.....	.....	.....	8	.....	.....	.....	.....
Husker-shredders	.....	8	11	15	5	12	9	17
Ensilage cutters	.....	3	2	.....	2	10	11	.....
Potato planters	2	.....	4	8	6	17	36	8
Potato diggers	.....	.....	2	.....	5	12	9	.....
Manure spreaders	84	91	91	77	65	77	82	50
Wagons	103	103	98	85	149	130	118	83
Total	1,210	1,374	1,356	1,329	1,290	1,565	1,592	1,070

TABLE VIII.—Estimated number of acres covered per 10-hour day with selected tools drawn at various speeds*

Speed	One-bottom 14-inch plow	Six-foot single-section disk	Five-foot mower	Two-section 10-foot drag or harrow	Two-row corn planter, 42-inch rows	One-row cultivator	Six-foot drill
Miles per hour							
1.0	1.2	6	5	10	7	3.5	6
1.5	1.7	9	7.5	15	10.5	5.2	9
2.0	2.3	12	10	20	14	7	12
2.5	2.9	15	12.5	25	17.5	8.7	15
3.0	3.5	18	15	30	21	10.5	18
3.5	4.1	21	17.5	35	24.5	12.2	21
4.0	4.6	24	20	40	28	14	24

*Speed in miles per hour times width of machine in feet equals acres covered in a 10-hour day.